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Applying the theory of chaos and a complex model of health to establish relations among financial indicators

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Abstract

They were applied the chaos theory and a complex model of health to determine relationships among aggregate indicators of financial statements. Cash flow, profit and loss, and assets of 70 companies in the sector of crude oil mining and natural gas in Colombia, were analyzed. Natural logs and Lorenz equation were applied to transform cash flow, profit and loss, and assets, resulting in an explained variance of 73% in the linear regression among the new complex indicators. The explained variance without transformations was 6%. However, these transformations make it more difficult to interpret the financial indicators.

Keywords: chaos theory; health; complexity; financial statements.

1. Introduction

Due to the high volatility of the economic sectors in certain countries, approaches to collect such volatility and to allow for more reliable predictions are required. Complexity and chaos models allow studying nonlinear phenomena in a determinist manner, focusing on strange relations among several types of variables and providing mathematical models to analyze changing behavior. Chaos theory has been applied to organizations [1] and it has been pointed out that many financial indicators are of chaotic nature [2]. The perspective of complexity also allows for a metaphorical language in different areas [3].

Health models provide a consistency existence of several indicators, while allowing for the simultaneous presence of positive and negative concepts of health. In this sense, health and illness are not considered opposite [4] and absence of illness does not guarantee health [5].Health can be defined by global indicators, like wellbeing, subsuming many aspects of individuals [6] at the person level [7]. This type of indexes integrate several health concepts [8, 9, 10], or dimensions, and they become complex because these concepts can be opposite but be all present at the same time, with no clear limits among them.

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According to the aforementioned, the purpose of this research was to evaluate the usefulness of chaos theory and a complex model of health, to obtain reliable relationships among aggregate indicators of financial statements and to determine what the differences are between this approach and another based on linear relationships among aggregate indicators.

2. Method

2,1 Sample

The financial statements of 70 companies in the sector of crude oil mining and natural gas in Colombia, as reported by the Corporate Supervision (Superintendencia de Sociedades), were analyzed. Completed financial statement, with no missing information, was a filter criterion. No difference was made among types of activities within the sector, company size or other.

2,2 Variables

Cash flow, profit and loss, and assets were considered as global indicators of financial health.

2.3 Analysis

They were applied log transformations, Lorenz equation and linear regression models to data.

3. Results

Figure 1 shows the position of each company, by cash flow, profit and loss, and assets, in a three-dimensional graph. As it can be observed, the data grouped in the upper left corner. Considering cash flow as a dependent variable, and profit and loss and assets as independent variables, and computing a linear regression with the data, resulted in a poor explained variance (6%) and a lack of significance of the regression model ($F = 2.245$, $p = .114$). This was due to the nonlinearity of the relations among variables.

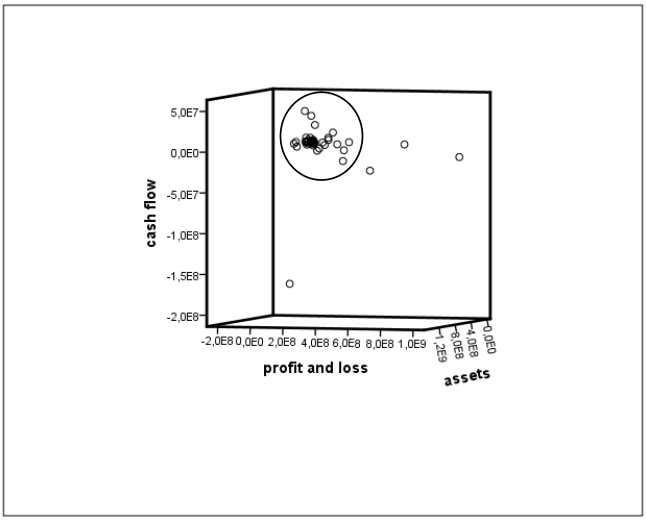

Figure 1. Companies of crude oil mining and natural gas in Colombia, by cash flow, profit and loss, and assets.

To solve this problem and to obtain a better prediction, they were applied natural log transformations to cash

flow, gain and loss and assets. This drew a grouping in the way it is showed in the Figure 2.

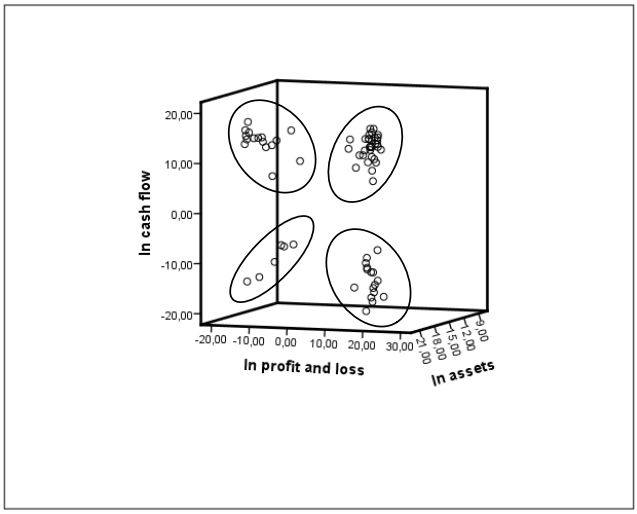

Figure 2. Companies of crude oil mining and natural gas in Colombia, by ln (cash flow), ln (profit and loss), and ln (assets).

In this figure, data grouped in four clusters, located in the four quadrants, but without a linear relation among them. Although these data do not fit the characteristics of a nonperiodic system, this special clustering reminds of the image of butterfly wings, from the chaos theory. In consonance with this intuition, the Lorentz equation [11] was computed with the log-transformed data. The equation is written by:

$$dx/dt = a(y - x) \quad (1)$$
$$dy/dt = x(b-z) - y \quad (2)$$
$$dz/dt = xy - cz \quad (3)$$

To fit the financial indicators to the equation:

Let x be ln (profit and loss).
Let y be ln (cash flow).
Let z be ln (assets).
Let a be 10, which is the Prandtl number.
Let b be 0, which is the Rayleigh number. This number is varied, and in this case, zero allows for the best results in the subsequent calculations.
Let c be 8/3, which is a standard value.

Fitting the three coordinates to this equation leads to

$$x = dx/dt = 10((\ln(\text{cash flow})) - (\ln(\text{profit and loss}))) \quad (4)$$
$$y = dy/dt = (\ln(\text{profit and loss}))(0-(\ln(\text{assets}))) - (\ln(\text{cash flow})) \quad (5)$$
$$z = dz/dt = (\ln(\text{profit and loss}))(\ln(\text{cash flow})) - (8/3)(\ln(\text{assets})) \quad (6)$$

Computing this equation, it gave the grouping showed in the Figure 3, with strong linear relations among the new variables.

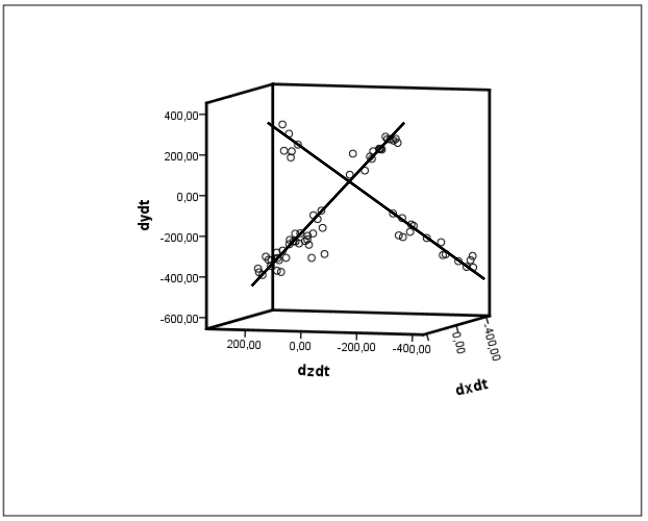

Figure 3. Companies of crude oil mining and natural gas in Colombia, by dx/dt, dy/dt, and dz/dt (see explanation in text).

Considering y (dy/dt) as dependent variable, and x (dx/dt) and z (dz/dt) as independent variables, and computing a linear regression, it resulted in an explained variance of 73%, and a good significance coefficient ($F = 92.046$, $p = .000$) for the regression model. The final formula, including non standardized coefficients of the variables in the model, is:

$$dy/dt = (1.017dx/dt) + (-.453dz/dt) + e \quad (7)$$

In this equation, dz/dt has a negative influence on dy/dt, while dx/dt has a positive influence, being *e* the error term. From this, it can be obtained appropriate formulas to observe the influence of individual variables on one another.

4. Discussion

In this application of a health model, the complexity is provided by the fuzzy boundaries among indicators of financial health and the inter-relationships among them, which comprised the same variables, i.e. cash flow, gain and loss, and assets. Fuzzy models have been introduced by several authors in financial prediction.

Financial health adopts a nonlinearity and complex behavior, as long as log transformations and Lorentz equation, computed with the data, resulted in a better prediction. The linear nature of the final regression model must not be confused with the linearity of the original data, which doest not exits.

Chaos theory has long been introduced in the analysis of the financial markets (see [14, 15]), but on this occasion, the use of the chaos model followed a intuitive approach, in the sense that the Lorenz equation was just used to produce a new rearrangement of the data, the same data that they were suppose to have previously generated, if the clusters were a result of a nonperiodic system with the characteristics of the Lorentz attractor. Even so, this approach was effective in making predictions about financial activity.

However, the new financial indicators were the result of transforming the original ones by several calculations, and there were no clear boundaries among them, because they consisted of different mixtures of the same set of variables. This makes them more difficult to interpret.

5. Conclusion

The application of complex health models and chaos theory (Lorentz attractor) was effective in the prediction of financial indicators and the position of each company within the sector. Nevertheless, due to the exploratory nature of this study, it is needed to go deeper into the analysis of the new complex model.

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